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OF  
THE ENGINEERING SOCIETY  
OF  
THE LEHIGH UNIVERSITY.

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JUNE, 1886.

# ENGINEERING SOCIETY JOURNAL.

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ABSTRACT OF PROCEEDINGS.

March 18, 1886. The chairman of the committee representing the School of Mines called the attention of the Society to the Mersey Tunnel, between Liverpool and Birkenhead, and gave a brief description of it. Mr. J. W. Kittrell was elected a member of the Society. Mr. F. W. Fink read a paper on "A New 'I' Beam." Discussions on various subjects followed, among them "The Shortest Route to the North Pole."

April 1. Messrs. Howard and Van Kirk were elected members. The chairman of the committee on Mechanical Engineering gave a brief review of the system employed in telegraphing to and from moving trains. The committee on Mining Engineering reviewed the latest improvements in the Clapp-Griffith steel-making process. Papers were read on the "Limiting Span of Suspension Bridges," by Mr. Hopkins, '84, read by Mr. Fink. "The Construction of Light Houses," by Mr. Bonnot.

April 15. Mr. H. Woods was elected an associate member, and Mr. Scull an active member.

Mr. C. H. Veeder read a paper on the "Manufacture of Horse-Shoe Nails." Specimens of nails which had undergone various tests, were exhibited to the Society. Mr. Seibert introduced an interesting discussion on the various slopes in the University Park. Mr. Phillips discussed the recent wash-out in mass, where 150 ft. of rails and ties were supported by two spikes.

April 29. Mr. R. L. Whitehead was elected an associate member. Mr. Reist called the attention of the Society to the new method of casting iron, known as the "Mitis" casting, by adding a small per cent. of aluminium.

Mr. LaDoo read a paper on Stadia Work. Mr. Hittell introduced a problem in Railroad Curves, which was fully discussed.

May 20. Mr. G. Lopez de Lara was elected Vice-President; Mr. Seibert having accepted a position on the U. S. Geological Survey. Papers were read by Mr. Pratt on the "Rainfall at Bethlehem;" by Mr. de Lara on "The Water Supply of Guadalajara;" by Mr. Howard, "Would a Machine-Shop be Beneficial to Lehigh?" The last paper led to considerable discussion.

May 27. This being the last meeting for the year, reports were presented to the Society by the Librarian, the Treasurer, and the Editors of the JOURNAL. The following officers were elected for the ensuing year: *President*, Mr. J. W. LaDoo; *Vice-President*, Mr. J. M. Howard; *Secretary*, Mr. M. D. Pratt; *Treasurer*, Mr. C. C. Jones; *Librarian*, Mr. A. Bonnot; *Editors*, Messrs. E. S. Stackhouse and B. A. Cunningham. The President delivered his farewell address. The Society adjourned to meet September 23, 1886.

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## THE FUTURE WATER SUPPLY OF THE CITY OF PHILADELPHIA.

The establishment of a system of water supply to any modern community is a problem which practically has no end.

The wants of one generation exceed those of the preceding, and the estimates which would be made for future requirements would be found to be too small. Such at least has been the history of most all the water supplies of American cities. From the intimate relation of the water supply to the public health, as well as to moral interests, it is seen that greater attention should be given to this important problem.

Among all the complex problems that have arisen in city engineering, there is none that demands so much attention and more thought than the integrity of the water supply.

There is scarcely any city in the civilized world that has not sooner or later been compelled to confront this problem. London, Paris, Berlin, New York, Brooklyn, Boston, and several others, being forced by the increasing contamination, and the want of a

good supply, have successfully overcome their respective difficulties, and are at present still laboring to maintain that purity and abundance of water which is universally recognized as a vital necessity.

Philadelphia established the first public water supply in this country. Suitable alterations and enlargements were made from time to time, but they were unable to keep pace with the rapid increase of population, and as the population increased the pollution of the water was increased in the same proportion. The city of Philadelphia obtains its water principally from the Schuylkill River. When the public water supply was established, the Schuylkill furnished a sufficient amount of wholesome water, and it was so plentiful that it was even used to drive the wheels by which the water was taken out of the river and distributed through the mains. Later on, the coal and iron industries came into existence, railroads were built and numerous mills and factories discharged their waste matter into the stream. The increasing contamination was soon felt, and as early as the year 1824 steps were taken, which at that time were supposed to guard against it. In 1832, an act was passed inflicting a punishment upon any person wilfully discharging any noxious matter into the stream. It was in the year 1860 that the first complaints were received, stating that the water had a foul taste and smell. From time to time commissions were appointed for the purpose of investigating the supply, and adopting such plans as should protect it from contamination. No definite steps however, were taken until the year 1875, when a commission of Engineers was called together by the Mayor. This commission investigated the matter very thoroughly, and submitted a report in which they treated the pollution at great length, and proposed methods of averting and decreasing it.

From this report we obtain a table from which can be seen the rate of increase of population, the total consumption, and the quantity consumed per head:

	POPULATION.	CONSUMPTION.	QUANTITY PER HEAD.
1810	96,287	669,041 galls.	7 galls.
1830	167,080	2,676,164 "	17 "
1850	408,762	8,697,534 "	21 "
1870	674,022	36,720,030 "	55 "
1884	956,000	69,658,969 "	73 "

The population of Philadelphia is nearly 1,000,000, and it is quite probable that within one generation it will be nearly twice that number.

The average daily pumpage is about 70,000,000 gallons, and

from the history of the growth of manufacturing industries, and the extension of sewer systems, it is found that the consumption *per capita* increases with the population. From present calculations, it is shown that the city of Philadelphia will require 200,000,000 gallons 50 years hence, or at least it would not be safe to calculate on a smaller quantity. It is plainly seen that the Schuylkill will barely be able to supply this quantity throughout the entire year. They have finally come to the conclusion that they must abandon the Schuylkill as the source of their water supply, and their attention is at present called to search for some other practicable source. In 1865, the Chief Engineer of the Water Department advocated using the water of Perkiomen Creek, and the construction of a reservoir near Swentsville. The commission of 1875, after fully considering this subject, came to the conclusion that the Perkiomen could not furnish the full quantity of water required. Their attention was then called to the water of the upper Delaware. From the surveys, it is found that if the water were taken about half-way between Easton and Trenton, the cost of the conduit to lead it into the city would be nearly the same as if the Perkiomen water were used. The Lehigh River was made a third possible source of supply. It is true that the water of the Lehigh is not found in excessive quantities, but it is unsurpassed in purity and wholesomeness. Besides, the topography of the country is such that dams could be easily and cheaply constructed, and the water could be carried at such elevations that there would be no danger of pollution; besides, it could be conveyed to the city by gravity alone. In the surveys above referred to, the different rivers were gauged for the purpose of ascertaining the quantity discharged, and it was found that the minimum flow of the Delaware at the Water Gap in Sept. 1883, was 700,000,000 gallons. The minimum flow of the Lehigh at White Haven in Oct. 1884, was 127,000,000 gallons. From these figures it is seen that the Delaware furnishes a most abundant supply for many years to come.

Lastly, attention has been called to the water pumped from the zinc mines at Friedensville. The water is clear and pure, and pleasant to the taste. The quantity pumped from the mines is about 30,000,000 gallons per day. This quantity is not sufficient to supply the city of Philadelphia, for we have already seen that the consumption of water in 1884 was 73,000,000 gallons.

It has been suggested that the Schuylkill water should be used



for all purposes except culinary and drinking purposes, for which the Friedensville supply should be used. The question naturally arises whether this would be a practical method of supplying wholesome water. There would have to be two systems of mains; and meters would be required to reduce the great waste of the better water which would otherwise occur. This method of supplying good water for drinking purposes has been carried out in Paris, and in a report by M. Guillimain in the "*Annals des Ponts et Chaussées*," for April, 1885, is extracted the following: "In 1854, the daily supply per inhabitant was 15.6 gallons, but the water was of poor quality, being warm in summer and muddy in the winter." At the present time the supply per capita is 57.2 gallons. The establishment of two separate systems of supply is due to Belgraud. The pure water is obtained from the Dhuis and the Vanne, distant about 80 miles, and is conducted into the city by means of aqueducts and siphons. When it reaches the city it is stored in immense distributing reservoirs of masonry, which are covered to resist atmospheric influences. The other water is taken directly from the Seine and the Marne, and distributed into the mains. The expense incurred by establishing such systems would be great, but pure water can be furnished by this method, and the supply per capita can be materially reduced by the use of meters.

All these different sources of supply must be carefully considered before a final decision is made. As a rule, however, mankind must continue to rely upon natural courses for their supplies. Knowing that a large supply of pure water is essential to the health and happiness of mankind, we should grasp at any means by which such may be obtained.

L. J. H. GROSSART.

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#### THE DIRECT PROCESS AS USED IN THE EDGAR THOMSON STEEL WORKS AT BRADDOCK, PA.

The use of the cupola for remelting the pig iron before using it in the Bessemer converter is still the rule in American steel works, whilst in England and on the Continent it is being gradually done away with.

Of the twenty-two Bessemer steel plants in this country we find that only three of this number are using the direct process; these three are the Edgar Thomson, the South Chicago and the Joliet

Works. In this sketch I propose to give a short description of the practice in the first mentioned one, the Edgar Thomson.

The converting mill of this plant contains three ten-ton vessels, side by side, with their axes in the same straight line and at the same height above the pit level 4m. 80c.; directly behind them is the brick wall that separates the converting mill from the cupola building, the cupolas in the latter, of course, being now supplanted by the newer method; in this wall, which is composed of fire brick, are three low arches, one behind each vessel, and through these arches are placed the runners in which the molten pig runs from the ladles to the vessels.

The blast furnaces, five in number, are about a half a mile away and on lower ground than the converting mill. Four of these are run upon Bessemer pig all the time, whilst the fifth and smallest one is used to produce spiegel and ferromanganese. These furnaces produce from 200 to 250 tons per day. They are built with an ordinary casting house, which can be used for ordinary pig casting when necessary; this, of course, being done on Sunday, when the converting mill is not running, no trouble is experienced at these works in getting rid of this pig, since it can be used for recarbonizing metal during the week. Along one side of each furnace cast house are tracks sunken slightly below the general level, so that the direct ladle can be run down them and be under the end of a long runner coming from the tapping hole of the furnace. These ladles are made of iron, lined with ordinary fire brick and carried on a four-wheeled spring truck.

When a furnace is ready to cast, four ladles are pushed in beneath the ends of the runners and the metal is then tapped, the ladles being filled one after the other. While this is being done, two samples are taken, one being cast into a small chill mould and the other granulated by pouring into a bucket of water. The first is the furnace man's sample, which is broken when cold and the metal graded from it; the second is the laboratory sample, in which a rapid determination of silicon is made for the use of the "scraper." When the ladles are full a covering of coke dust is shoveled on the top of the metal in order to prevent the formation of too much "skull;" they are then pulled out from beside the cast house by a locomotive and weighed on a track scales. Ten tons is the supposed capacity of a ladle, but often they contain twelve tons and over. From these scales the track commences to rise rapidly, taking a long and easy curve at the same time in

order to get around the end of the line of blast furnaces, as the converting mill is behind them. Owing to this curve the distance is increased, making it at least two-thirds of a mile that the molten metal must be moved. The track is now carried on a wooden trestle, crossing the B. & O. R. R., still rising and finally terminating along the converting mill on a level with the axes of the vessels and at right angles with them. On account of the heavy grade but two ladles can be pushed up at a time; on reaching the cupola house, one of these is run on a turn-table, revolved by hydraulic or steam power and pushed by a donkey engine into the building on a track parallel to the converters and close behind them. It is again weighed and another sample, similar to the furnace man's, is taken. The converter is now turned over so that the nose points through one of the arches in the brick wall. The ladle is slowly tipped by means of a gear wheel and worm attached to its side, and the metal poured from the top, falling into a short runner which carries it directly into the vessel.

By this time the "scraper" has received the silicon report from the laboratory, also the furnace man's grading, and has graded the metal from his own sample; from these three tests he can form some idea of the amount of scrap required; should any be necessary, a portion of it is put in the vessel before it is turned up. After the vessel is turned up and the blow has commenced, the heat of the blow is judged from the appearance of the flame; should the blow be too hot, more scrap is added through a cast iron pipe which comes from an upper floor through the wall between the cupola house and converting mill about  $45^{\circ}$  and terminates a few feet above the mouth of the converter. By this means any amount, and in this process very large amounts of, are often needed, can be added to the charge without turning the vessel down, thereby saving time and much hard labor. Should the blow on the contrary be too cold, the vessel is turned partially to one side, and the flame plays directly against the brick wall, the heat being reflected back into the vessel and the temperature of the blow, in consequence, being at once increased. The length of time required to blow a 10-ton heat varies greatly, depending on the composition of the pig-iron, which is constantly changing, different ladles from the same cast having often great variations in composition, the length of time the ladles have been standing, and the condition of the vessel itself. The time, however, may be roughly stated as between sixteen and twenty-five minutes. I have

however seen heats that were blown in less than fifteen minutes, and heats as well that took more than forty minutes; one heat, in particular I know of, that took sixty-five minutes.

As to the composition of the metal, the silicon is the element which is the most variable, that is the one which varies greatly enough to cause a notable increase or decrease in the heat of the blow. Metal has been converted at these works that contained over 5 per cent. of silicon, and one heat that contained 7 per cent. was successfully made into steel; the usual run is between 2 per cent. and 2.2 per cent. silicon.

As each furnace casts four or five ladles full at a time, it necessarily happens, since all cannot be blown at once, that some of them must be kept waiting for a considerable time. Two heats are quite often blown at once in the Edgar Thomson mill, which tends to decrease the delay, still the heat of the molten metal is not so much lowered by standing for an hour or more as one would suppose at the first glance. Molten metal, with not over 2.25 per cent. si. has been blown here after having been standing in the ladles for over four hours, and the results were perfectly satisfactory. The advantages claimed for this process are, among others, that there is less handling of the pig-iron, a saving of the fuel, stone and labor for smelting, and less loss from scrap, etc.

Its opponents claim, on the other hand, that, owing to the ever-varying composition of the molten metal, it is not possible to produce as good steel from it as from remelted iron; also, that from the same cause the vessel linings and bottoms are worn out faster.

The results at the Edgar Thomson do not support the above claims; no more second quality rails are produced in the rail mill nor more blooms chipped at the shears than when they used the Indirect Process. As to the life of their vessel bottoms, these now stand from ten to twelve blows, say from 100 to 120 tons of pig metal converted on each bottom, which is fully up to the average of works using the Indirect Process.

JACOB S. ROBESON.

## THE MANUFACTURE OF HORSE-SHOE NAILS.

Until within about fifteen years all nails used in shoeing horses were made by hand, although of course the common cut nail is much older. As might have been expected, when machine-made nails were first introduced, the blacksmiths eyed them with great distrust, but now they have almost entirely superseded hand-made nails, in this country at least. In England, the making of hand-nails was a regular manufacture, and I believe is still carried on in a few factories there. Some of the scattered nailors, who lived in the smaller towns, used to practice what seemed to be a very curious paradox. The blacksmiths



the white-hot rod, and so worked in the slag thus formed that at the end the nails weighed more than the iron from which they were made. Another curious process was used. Beside the anvil was a small circular bellows, about a foot in diameter and fifteen inches high. A handle and weight were fastened to the top board, and from the bottom board extended a tube, with a small nozzle like a blowpipe, which was directed to the spot on the anvil where the nail was hammered. The top of the bellows was raised, and then the glowing rod was removed from the fire to the anvil, where the jet of air was blowing. The air, instead of cooling off the rod as we should naturally expect, caused a rapid combustion of the iron, thus keeping the rod hot for some time, and enabling the nailor to make several nails with one heating of the rod.



A good horse nail must be solid, so that it will not split, and it must be stiff enough not to bend more than the proper degree when being driven through the hoof, and yet be capable of being clinched on the outside without breaking. The iron at the neck must be tough and strong, so that it can withstand the constant jarring to which it is subjected by the horse. For this reason the head is given the peculiar shape which distinguishes it from the common nail, and prevents our upsetting the head like an ordinary nail.





The end of the nail is beveled on one side, so that although it is driven into the bottom of the hoof parallel to the side, it will bend inside the hoof and come out at the side about an inch above the bottom, and it is then cut off and clinched.



Machine-made nails may be divided into two classes: those which are cut from a flat bar, generally cold, in a more or less finished state, and those which are forged hot on the end of a rod. In the manufacture of cut nails the proper thickness is given to the head and body by rolling the bars with ridges, and their outline is determined by the shape of the dies. The nails are cut either transversely across the grain of the iron or longitudinally; the latter being far preferable. Sometimes short stubs are cut, and then these passed through rollers, in which cavities are formed to give the required shape.

The trouble with all cut nails is that the shearing injures the iron, rendering it liable to split and break, so that although cheaper than forged nails, they are not so much used as the latter. In forging nails the end of the hot rod is shaped either by rapidly reciprocating dies or by a combination of dies and a small rapidly moving roller. A machine of the latter kind was invented by one Mills (?), and used in the Saranac Horse-Nail Factory at Plattsburgh. It may be described as follows: "A rectangular frame, about  $2\frac{1}{2}$  ft. square, is supported by four legs about  $2\frac{1}{4}$  ft. high. At either side of the frame a little forward of the centre are two uprights, about a foot high, carrying bearings at their upper ends, in which runs the main spindle. This is driven by a belt-pully at its outer end and carries at its centre a "roll stock," in which is held a roll about one inch in diameter; the roll revolves in a circle nine inches in diameter. Below the main spindle, and at right angles to it, is another shaft, the centre lines being about eight inches apart. This is driven by suitable gearing from the main spindle, the velocity ratio being 1 to 11. This lower shaft carries a drum or head directly under the revolving roll, and in this head are set a series of anvils or dies, so shaped that the roll in passing over them will give the proper thickness to the head and body of the nail; both the roll and anvils are of chilled cast-iron. The side blows are given by steel dies held in two hammers which are revolving on centres below the lower shaft. These hammers receive their motion through pitmans with ball-and-socket



joints from two eccentrics on the main spindle. A "gripe" at the front part of the frame holds the rod while it is being hammered, and the rod is also guided by a funnel-shaped 'nose piece' immediately in front of the anvils and dies. The gripe is raised for a short time during every revolution of the lower shafting, to enable the rod to be inserted and pushed forward. Beside each machine is a small furnace, burning hard coal, in which about a dozen rods can be heated at a time. The hot rods are taken from the furnace and with a quick movement of the hand are thrust through the nose-piece until they strike a gauge or stop on the revolving anvil head, and then under the raised gripe. After being hammered as above by the rolls and dies, the 'blank' is cut off by cutters working on the lower or anvil shaft, and then drops into a pan below the machine. Five or six nails are made from a rod before it is taken out of the machine and reheated. The blanks are made at the rate of about 64 per minute, and it takes 11 revolutions of the main spindle to each blank. These 'blanks' are now assorted by boys and must then be finished. They are covered with scales of black oxide, and are soft and have square points. They are first put into a cast-iron tumbling barrel with saw-dust, and in about three or four hours they are taken out bright and polished. Then they are taken to the finishing machines or 'pointers.' Here they are fed by small boys into notches cut in the edge of a horizontal iron ring, about 18 inches in diameter. This ring receives an intermittent rotary motion by means of a ratchet and pawe, and carries the nails first before a reciprocating roller which rolls them out slightly and gives them the requisite stiffness; then they are nicked by a very blunt punch or chisel to form the bevel at the point, and then the top or point is formed by suitable dies which shear off the sides. The nail is then released and placed in a wooden tumbling-barrel to remove any slight burn or 'wire edge' left by the shears. The nails are again assorted, this time by nimble-fingered girls, and are then ready to be packed into boxes, holding 25 pounds."

The factory is a very noisy place; conversation can be carried on only with great difficulty, and on a still day I have heard the rattle of the machines over a mile away.

It is also very hot in summer, standing before the furnaces. I have seen the thermometer hung on the neck of one of the nailors register 140°. But to offset this they are well paid. They work by the pound, and often make \$3 and even more per day. Eighteen

machines make 200 pounds of nails per day each. The iron used was at first forge iron made in the Catalan forges near Plattsburgh, but afterward Swedish or Norway iron, star and crescent brand, was used. It cost \$80 per gross ton delivered in Plattsburgh. About 15 per cent. of the iron is wasted during the various processes. The finished nails vary in price from 26 cents per pound for the smallest, to 18 cents for the largest size, with a discount of 30 per cent.

There are extensive horse nail factories in Keesville, N. Y., Vergennes, Vt., Chicago, and also, I believe, in Montreal.

C. H. VEEDER.

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### "WOULD A MACHINE SHOP BE BENEFICIAL TO LEHIGH?"

The student who possesses both theoretical and practical knowledge is the successful and accomplished Engineer. It is not enough to aim at securing practical achievements. The scientific attainments necessary to the Engineer are more than knowledge of facts and principles. The proof of such attainments is the ability, within a sufficiently wide range of inquiry, to give accurate answers to definite questions; to solve engineering problems by the best and most direct methods; to originate and properly conduct investigations and experiments relating to the many questions which constantly arise in engineering design and construction.

The close relation which the machine shop bears to both the scientific attainments and practical achievements of the Engineer, is very obvious. The machine shop is an institution in itself. It has its own methods and processes, its standards of machine design and workmanship, its tools and facilities.

It is clear, that an Engineer, in order to properly prepare his work for the shop, must know the shop methods, limitations and possibilities.

Is it probable that we would ever have such a shop? The object of the shop department should be to supply new means of instruction in mechanical and engineering work. A room filled with machinist's tools, where curious things are made by processes chosen by the maker, for no purpose but the practice of making



them, is not a machine shop in any practical sense. If we should have a shop at Lehigh, it should be superior in all its appointments. It should not only have the tools, methods and facilities, but also the skilled workmen and the business of a first-class shop. To aim at anything less than the best practice of the leading manufacturing shops would be to defeat one of the main objects of the shop department, and one of the special aims which should lead to the establishment of the department, if it should be established. If we should have a machine shop, we should also have a foundry and a pattern shop, to make a success.

At Cornell University they have a machine shop, and each student has nine hours per week to devote to it. At this rate, in four years we would get about 137 days of work in the shop, which is not a very long time to devote to such an important place.

Now, the question is this—do we have enough theory to study in the four years, or do we want about nine hours per week extra work in the machine shop? If we had connected with the M. E. department a suitable place with machine tools, and the students were allowed to take them apart and examine them so that they might see how they were constructed, and then learn how to put them together again, it would be a great benefit to the student without taking up much of his time. Then he would know how to draw the different parts; also, when going into a shop to learn the practical work, he would know something about the tools. The work of an Engineer has been defined as the overcoming of the resistance of nature, and the best Engineer is he who overcomes these resistances with the least amount of time, labor and money.

Could we do this at Lehigh? Not unless we had a good machine shop, pattern shop and foundry, with facilities for experimental work on mechanical problems; and it should be under a skilled and competent superintendent and a corps of suitable instructors and journeymen. To those who wish to be successful engineers, the practical work is very important, and if four years is necessary for the theory, would it not be advisable, after graduating at Lehigh (unless the student has had practical work before entering,) to go to some good works and work two or three years as may be required?

Then the theory and practice could be brought together. One would learn the best and quickest methods for doing different pieces of work; would be thrown with men who had worked at

different shops, thereby learning the ways of the different places; would be obliged to respect their ways of doing things, or else to suggest better ones; would feel more responsibility and more pressure to get his work done and to do it right, if he knows that it is being made for some purpose, and must be made right; would be more willing to remedy what would otherwise be deemed a slight mistake or to repeat the work, when wholly wrong. Such work in a machine shop results not only in skill, but in the kind of skill which practical men and superintendents recognize as valuable.

J. M. HOWARD.

### STADIA WORK.

The method of surveying by transit and stadia is fast coming into popularity, and where rigid accuracy is not so important as quick work, this process, with its many and varied applications, far supersedes any other yet known. For many years it made little progress, owing probably to the fact that most engineers believed the method too inaccurate for ordinary surveying, and besides, until lately, the written information upon the subject has been very meagre and unsatisfactory. Recently it has been demonstrated by experiment that with proper instruments and ordinary care the distances obtained by the use of transit and stadia are quite as accurate as those obtained by good chaining, in which the error is about 1 in 1000, or one inch to eighty feet.

The method was first discovered and applied by an Italian about the year 1820, and it had not been used in this country until 1850, when Mr. J. R. Mayer, C.E., brought it from Switzerland. He wrote an essay upon the subject for the "Journal of the Franklin Institute for 1865."

It is not my intention to attempt to develop the theory of this process; all that will be found in any recent text-book on surveying; but in order to make clear what follows and preserve a certain completeness, it is necessary to either deduce or assume one or two fundamental working formulas.

Let the transit be stationed at  $P$ , the telescope inclined, and the rod be held vertical at a distance  $r$  from the centre of transit.  $F$  is a point on the line of collimation (generally nine or ten inches forward of centre of instrument) from which measurements made to the rod will be in exact proportion to the distances

cut off on the image of the rod by the image of the stadia hairs. This point, for the same instrument, is at a constant distance from the centre, equal to the focal distance of the telescope plus the distance from the centre to objective, when the instrument is focussed on a distant object.

Let  $G$  be the point of intersection of the rod and the line of collimation;

$l$  be the reading of the rod;

$l'$  be the reading of the rod when the rod is held perpendicular to the line of collimation;

$a$  be the angle between the two positions of the rod;

$\delta$  be the angle of elevation of the telescope;

$r'$  be the horizontal distance from  $F$  to the rod.

By similar triangles  $\delta = a$ , and if the rod is divided to such a scale that  $l'$  represents the true distance to  $G$ , the following formulas are readily deduced:  $l' = l \cos. \delta = FG$ ; but  $r' = FG \cos. \delta$ ; hence  $r' = l \cos.^2 \delta$ , which may be written  $l - r' = l \sin.^2 \delta$  (1). So we see that the true distance from the centre of the instrument to the rod is  $l \cos. \delta$  plus a constant  $c$ , and the horizontal distance to the rod is  $r = l \cos.^2 \delta + c \cos. \delta$  (2), the last term of which is often neglected entirely, and its value can always be assigned within an inch without computation;  $l - r$  is the correction to subtract from the reading  $l$  to get the true horizontal distance  $r$ . For the height above the centre of the instrument:  $h = l \cos. \delta \sin. \delta$  (3) or  $h = \frac{1}{2} l \sin. 2 \delta$  (4). Tables have been arranged for the reduction of these equations, but in order to avoid multiplications and interpolations, they are necessarily too voluminous for ordinary field use. For this purpose diagrams have been made, which are as accurate as the tables, require no computation and are very easily read. Knowing the angle of elevation and the observed stadia readings corresponding to angles of elevation less than  $20^\circ$ , two observations on the diagram will give the correction to horizontal distance and the difference of elevation between the station and observed point. As I have not seen a description of this particular diagram, I shall give a brief explanation of its principle and construction. Taking the equation  $l - r = l \sin.^2 \delta$ , which may be written  $(l - r') \frac{1000}{l} = 1000 \sin.^2 \delta$  we find values for  $1000 \sin.^2 \delta$  from  $2^\circ$  to  $20^\circ$ , for instance, including minutes and lay off these distances on a line  $AK$ , from  $A$  upwards. From  $A$  and perpendicular to  $AK$  draw  $AB = 1000$  ft. suppose, and from  $B$  draw diverging lines to the points of division of  $AK$ , which, or some line  $BM$  par-

allel to it, is divided to scale the same as that used in laying off distances on  $AK$ . ( $AB$  is not divided to that scale.) Each of these diverging lines is marked with the length in degrees it cuts off on  $AK$ . If  $l=1000$  the distances from  $A$  to the points of intersection of the diverging lines with  $AK$  will give values of  $l-r'$  directly for varying angles  $\delta$ . These corrections are to be subtracted from  $l$  to give  $r'$ . But we wish to make the diagram applicable to any reading  $l$ . Now, since the value of  $l-r'=l \sin.^2 \delta$  varies directly as  $l$ , if that reading be  $l=500$  ft. or any number less than 1000, and we erect ordinates, perpendicular to  $AB$ , it is evident that these, limited by the intersections with the diverging lines, will represent the true corrections to the readings for the respective angles  $\delta$ .

It is to be noted that the horizontal scale is entirely independent of the vertical, and the vertical distances are in the same denomination as we have chosen  $l$ . Suppose the reading is  $l=500$  ft. and  $\delta=4^\circ$ . We measure from  $B$  out towards  $A$  500 ft. (to scale) and erect an ordinate at this point. The distance on this ordinate to where it intersects the diverging line marked  $4^\circ$  is the required correction. This point of intersection is carried over to the scale by a line parallel to  $AB$ . In the same manner the equation is solved for any values of  $\delta$  and  $l$ . In order to lay off the lengths of  $1000 \sin.^2 \delta$  for angles greater than  $7^\circ$  or  $8^\circ$ , it would be necessary to reduce the vertical scale to keep within convenient limits of paper. The reason why we take  $l$  as 1000 is to so multiply the scale that the values of  $\sin.^2 \delta$  become appreciable and can be laid off with an ordinary scale; otherwise the points would be so close together that they could not be read. To reach as high as  $20^\circ$  at least two diagrams would be necessary, one in which the scale is multiplied by 1000 the other by 100. A diagram can be constructed in exactly the same manner for the expression  $h=l \cos. \delta \sin. \delta$ .

Another very simple and elegant manner of determining the value of these expressions is by means of a logarithmic slide made of some inexpandible material, and constructed as follows. Let the expression be  $h=l \sin. \delta \cos. \delta$ . Find the logarithms of  $\sin. \delta \cos. \delta$  for all values of  $\delta$  likely to be encountered, and lay them off on a slide  $s$ . Upon the scale  $c$  on which  $s$  slides lay off in an opposite direction, commencing with the logarithm of one equals zero, and ranging to the limit of  $l$  likely to be met with. If  $l=316.3$  and  $\delta=20^\circ$  we have  $h=l \cos. \delta \sin. \delta = 316.3 \times \cos. 20^\circ \sin. 20^\circ$ .

$$\begin{aligned} \log. 316.3 &= 2.50010 \\ \log. \sin. 20^\circ &= 9.53404 \\ \log. \cos. 20^\circ &= 9.97299 \\ \hline &2.00714 \end{aligned}$$

and 2.00714 is the logarithm of 100 approximately, which is very nicely given by the diagram. Place the zero mark (corresponding to  $90^\circ$ ) of  $s$  on 316.3 of  $c$ , and glance back to the  $20^\circ$  mark of  $s$ , under which we find the number corresponding to the sum of the logarithms of  $l$  and  $\cos. \delta \sin. \delta$ , or the required product  $h$ . The management is extremely simple, but the graduation must be nicely done to get good results on the scale. Of course more than one scale can be put on the same slide, so that this arrangement can be used to solve two different equations. In order to determine the expression  $l \sin.^2 \delta$ , a division could be made which would give the logarithms of  $\sin.^2 \delta$ , but as we have

$$\begin{aligned} \log. \sin.^2 0^\circ 34' 20'' &= -4 \\ \text{" } \sin.^2 1^\circ 48' 50'' &= -3 \\ \text{" } \sin.^2 5^\circ 44' 0'' &= -2 \end{aligned}$$

this division, of which the importance is secondary, would already require the whole length of the scale; that is, notwithstanding the great exactness of which it would admit, we have to discard this method for these values, and must arrive at the solution by other means:

$$\begin{aligned} \text{We have } \sin.^2 1^\circ &= 0.000305 = \frac{1}{32} \text{ in a hundred.} \\ 2^\circ &= 0.001220 = \frac{1}{8} \text{ " " } \\ 3^\circ &= 0.002740 = \frac{1}{4} \text{ " " } \\ 4^\circ &= 0.004870 = \frac{1}{2} \text{ " " } \\ 5^\circ &= 0.007600 = \frac{3}{4} \text{ " " } \\ 6^\circ &= 0.100900 = 1 \text{ " " } \end{aligned}$$

These numbers can be easily retained in the mind, and by a simple mental multiplication of the reading we get the required correction to be subtracted from  $l$  to get the horizontal distance; for instance, if  $l=168$  and  $\delta=2^\circ$  we have  $1.68 \times \frac{1}{8} = .21$ , and  $168 - 0.21 = 167.79$ , the true horizontal distance. The correction



is so inconsiderable that we can always neglect the reduction for angles less than  $2^\circ$ , and for angles greater than  $6^\circ$  we can employ the scale in the same manner as the last.

In measuring with transit and stadia great care must be taken to hold the rod truly vertical, especially when admitting angles of elevation. By means of the vertical hair the transit-man can ascertain if the rod be in the same vertical plane as the telescope, but it may incline toward or from him. However, with a little experience, a careful rod-man will be able to hold the rod so that its top will not incline from its foot more than  $\frac{1}{50}$  of its length. Allowing this deviation we have for

$\delta = 0^\circ$	the error is	0	per hundred.
$5^\circ$	" "	0.2	"
$10^\circ$	" "	0.4	"
$20^\circ$	" "	0.7	"
$30^\circ$	" "	1.2	"

The more diversified the accidents of the earth the more difficult to keep the rod vertical. For important points, and for those only, a spherical level is very efficacious in keeping the rod true.

In order to avoid calculations, which are always annoying, it is well to find the height of instrument and read the angle of elevation  $\delta$  for such a position of the telescope that the levelling hair will cut off on the rod a height equal to that of the instrument. If, as it often happens, on account of the difficulties presented by the accidents of the ground, as brush, etc., it is impossible to bring the hair to a height  $J$  we can take  $J+1$ .

With a good construction of lenses the hairs will remain constant for months, but it is well to have a distance and elevation exactly measured in a convenient place where the instrument can be tested from time to time.

In preparing this paper I intended to make some experiments to prove the exactness of stadia measurements, but in looking up the subject I succeeded in finding the record of an extended series of experiments, which were carried on for this purpose in France in 1879, by M. Stambach, a celebrated engineer. The line of sight was horizontal, a small terrestrial telescope, which magnified about 16 diameters, was used. The hairs were adjustable, and the condition of the atmosphere satisfactory. The first series were 18 in number, as follows:

## FIRST SERIES.

DISTANCES MEASURED.	OBSERVED.	DIFFERENCE.
67 m. 50 c.	67 m. 50 c.	0
63 80	63 80	0
61 60	61 50	-10
58 30	58 20	-10
50 90	50 95	+ 5
46 75	46 75	0
45 00	44 95	- 5
41 15	41 00	-15
39 50	39 55	+ 5
36 85	36 95	+10
34 35	34 50	+15
30 65	30 70	+ 5
26 55	26 50	- 5
25 00	25 00	0
21 55	21 60	+ 5
19 40	19 40	0
16 35	16 30	- 5
14 50	14 55	+ 5

The total error was 1 metre. A second series was 25 in number, as follows :

## SECOND SERIES.

DISTANCES MEASURED.	OBSERVED.	DIFFERENCE.
6 m. 40 c.	6 m. 45 c.	+ 5
9 65	9 75	+10
12 80	12 90	+10
14 65	14 80	+15
17 10	17 15	+ 5
19 50	19 50	0
22 20	22 15	- 5
24 00	24 00	0
26 55	26 50	- 5
29 40	29 50	+10
29 00	29 15	+15
31 05	31 05	0
32 95	32 95	0
35 75	35 80	+ 5
40 00	40 00	0
39 67	39 55	-12
43 00	43 00	0
44 80	44 90	+10
48 10	48 00	-10
50 00	49 95	- 5
49 61	49 60	- 1
49 90	49 90	0
51 80	51 85	+ 5
56 90	56 80	-10
60 00	60 00	0

The total error was 1m. 38c.; therefore the average error of both series was  $\frac{1 + 1.38}{18 + 25} = 5.5c.$ ; and the limit of error upon which we can safely rely is about 8 centimeters. It was remarkable that the errors did not increase in proportion to the distance. It was also demonstrated by a later series of experiments that a telescope of larger magnifying power tends to increase the accuracy; these were made on the 18th of May, 1883. Distances ranged from

4m. 30c. to 68m. 40c. The sum of the errors for 28 measurements was 130 centimetres; therefore,  $\frac{130}{28} = 4.6$  c., the average error. The greatest error in this set for a single reading was 20c.

In a subsequent paper, if time will permit, I propose to show how, theoretically, stadia measurements can be made with a much greater facility than has heretofore been attained.

J. W. LADOO.

## HISTORY AND METHOD OF CONSTRUCTING LIGHT-HOUSES.

Little is known of the early history of light-houses. The first light-house that is mentioned in history is the Pharos of Alexandria. The form of this building was the frustum of a square pyramid, and it was built in a very superb style; the dimensions of it are not known. It was begun by the first Ptolemy, and was finished in 280 B. C. The height was 400 feet, and Josephus said that a light on this tower could be seen 41 miles. Not a trace of this magnificent building remains, and it is thought that it was destroyed by an earthquake, at what time we do not know. The island upon which it was built was Pharos, and to this day the French word for light-house is *phare*, and the word in Italian and Spanish is *faro*.

One of the most remarkable of modern light-houses is the tower of Cordouan, begun in 1584 and finished in 1610 by Louis de Foix, taking 26 years to construct it. It is situated on a ledge of rocks at the mouth of the Garonne or Gironde, in the Bay of Biscay. The ledge is about 3,000 feet long and 1,500 feet broad, and is bare at low water. It is surrounded by detached rocks, upon which the sea breaks with great violence. The foundation is the frustum of a circular cone, whose lower base is 135 feet in diameter, and is built solid of cut stone to a height of 16 feet, a space for a cellar, and water cistern. The upper base of the frustum is 125 feet in diameter. The tower, 50 feet in diameter, springs from this level, rising 115 feet. Total height of tower from base to upper point of lantern dome is 146 feet, and from the rocks 162 feet.

Of other light-houses we have the Bell Rock Light-House,



situated on the East coast of Scotland. It was constructed by Mr. Robert Stevenson. The form is similar to that of the Eddystone Light-House. It was commenced in 1807 and finished in 1810. The difficulties of erecting this light-house were almost as great as those encountered by Smeaton in building the Eddystone Light-House; the large size of the rock upon which it was built was an advantage, however.

The Skerryvore Light-House off the West coast of Scotland is also notable on account of the difficulties met with in its construction. The Skerryvore rocks are situated in the track of large vessels from Glasgow and Liverpool, around the North of Ireland. A survey was made in 1834, and a solid gneiss rock of 160 feet long and 70 feet wide was discovered, upon which Mr. Alan Stevenson constructed it. It is very interesting to read of the dangers and difficulties Mr. Stevenson met with, and shows in work like this that the engineer must have unlimited patience. In one instance, when building this light-house, a huge storm arose and in a few hours swept away everything that had taken two years to build. The form chosen for the tower is a shaft surmounted by a belt and capital upon which is the parapet wall. The shaft is a solid of revolution, formed by revolving a rectangular hyperbola about its asymptote.

The Eddystone Light is celebrated on account of the difficulties attending its construction. The Eddystone rocks are in the English Channel, and are in the way of all the vessels coasting along the South of England. They are a cluster of gneiss rocks 600 feet to 700 feet long, from North to South, and about the same from East to West. The first light-house built upon them was commenced in 1696, and finished in 1699, by Henry Winstanley. We are not certain how this was built, but it is supposed to have been built upon a polygonal base 12 feet high and 24 feet in diameter, and built of wood, resembling a pagoda. Height of this to base of lantern was 75 feet. This building stood until November, 1703, when Mr. Winstanley went to the light-house with some workmen in order to make some repairs, and stated, before he left land, that he wished a storm would come up, so he could see how his light-house would stand it. He was too amply gratified, for, while he was there, a terrible storm arose and not a remnant of the light-house nor a trace of the inmates were ever seen. The second light-house was finished in 1709, by Rudyerd, a silk merchant; a queer sort of occupation for a light-house

builder, but he had two friends who knew something about building, and it is supposed they helped him. This building showed great advances in Engineering, and was built of wood and iron. The form was the frustum of a circular cone, built nearly solid for a height 27 feet above the rock. The filling consisting of courses of cut stone, alternating with courses of squared timber. The outside casing was composed of 72 oak posts or uprights, the lower ends of which were fastened to the rocks by heavy irons, which were let into lewis holes. This is the first recorded application of a lewis stone. In December, 1755, it was destroyed by fire, three years after being built. In 1759 Smeaton finished the Eddystone Light-House, taking three years to build it. He used stone for material, taking for his model the shape of a trunk of a tree. The stones of a course were joined by dove-tailing, and the different courses were connected by stone dowels. The upper surface of the rock was cut into horizontal steps, so that every course of masonry rests upon a horizontal bed. The form of this structure was a solid of revolution generated by a vertical plane, bounded upon one side by a concave curve, around a vertical axis. The strength in this tower is obtained by dove-tailing, cramping and dowelling, and by use of hydraulic mortar.

It is strange that Mr. Smeaton should have adopted an arched form for the floors of his building, instead of employing them as tie-walls formed of dove-tailed stones. To counteract the injurious tendency of the outward thrust of these arched floors, Mr. Smeaton had recourse to the ingenious expedient of laying in circular trenches or beds in the stones which form the outside casing, sets of chains, which were heated by means of an application of hot lead, and became tight on cooling.

The most solid light-house in this country is that of Hundt's ledge, off the coast of Massachusetts. It is about  $1\frac{1}{2}$  miles from the nearest land, and at low water the highest part of the rock is bare. This was a very difficult light-house to erect. The plan of the work was a regular octagon, each side of which at the base was  $9\frac{1}{4}$  feet, the diameter of the circumscribing circle being 25 feet. Iron piles 10 inches in diameter where they leave the rocks, were inserted into the rock 5 feet at each angle of the octagon and at its centre. These were firmly braced and tied together by wrought iron braces. At 55 feet above the highest point of the rock, the heads of the piles were firmly secured to a heavy casting. It was finished in 1849, and in 1856 was washed away

by a terrific storm. All the iron piles were twisted off at a short distance above their feet. One cause of the destruction of this light-house is supposed to have been by a hawser, which was fastened to the top of the structure at one end, the other end being anchored in the sea. The waves after leaving the light-house would strike the hawser, and the effect of the blow was transmitted to the pyramid with very great leverage, causing tendency to oscillate. Another cause was the ice which froze to the piles, and thus increased the extent of surface exposed to the action of the sea.

The work on the new light-house was begun in 1855, and not until 1857 were any stones laid, the whole time being taken up in leveling the foundation; in 1857 four stones were laid, in 1858 six entire courses were laid, and it was finished in 1860. The stones of the courses are dove-tailed, and the courses are fastened together by wrought iron dowels 3 inches in diameter. It is a granite tower, the frustum of a cone.

A. B.

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## RECENT MINE ACCIDENTS.

I propose this evening to give a brief description of two mine accidents, which occurred recently in the Anthracite coal regions, and which from their cause and character were very peculiar.

The first occurred at Mocanaqua, about the middle of August, 1885. Mocanaqua is on the opposite side of the Susquehanna River from Shickshinny, about 16 miles below Wilkes-Barre. It is near the lower end of the coal basin.

There is a slope inside of the mine, and the coal was brought up by an engine at the top of the plane. The circulation of the air was kept up by a fan, also situated near the head of this plane. As there was a great amount of power required to hoist the coal and run the fan, it was necessary to have several large steam boilers. I think there were six of them.

One night about 11 o'clock, the fan broke, and instead of drawing the fires at once they were filled up and left to burn. The fan was not fixed, and the next morning the men went in to work as usual.

Now during the time the fan was stopped, the air was becoming bad from two causes. 1. The fan being stopped, the circulation

of air ceased, and this alone would have made the air very foul. 2. The coal of the boiler fires was still burning, and filling the mine with a mixture of  $CO$  and  $CO_2$ . At first there was probably an excess of  $CO_2$  formed, but as the coal continued to burn and the  $O$  to be exhausted, most of it burned to  $CO$ . The specific gravity of  $CO=0.973$  and that of  $CO_2=1.524$ , so we see that the  $CO$  would tend to form a layer near the roof of the mine, while the  $CO_2$  would tend to go to the bottom. By the time the miners went to work in the morning the mine was full of these poisonous gases, and there was but little oxygen left in the air.

It was the mine boss's place to investigate the matter, and see if the air was good, but he neglected this, not thinking that the air would be so poisonous. So the men went to work as no notice had been given them. They knew that the air was bad, but did not know it was so deadly, and as the effects are sudden, most of them were in before they were overcome. The effect was of rather a pleasing nature. They became dizzy at first, but soon very weak, and generally fell flat on their faces, after which a feeling of peace and quiet came upon them, so that they would rather stay in the mine than be taken out, and many were taken out against their will.

On some it had the effect of making them crazy and wandering in the mind, so that they would wander off into abandoned parts of the mine and dance and sing; but they were finally overcome, and laid down to die.

As soon as the nature of the accident was known, relief parties were sent in, and many of these fresh men were overcome, and in fact several of them died from the effects of the gas, in attempting to rescue the others. Many of the miners were taken out, but there were eleven who were poisoned fatally. It was not difficult to revive those who were taken out of the mine alive, the method being to apply clay mixed with cold water to the hands, wrists, face, and breast, and not one who was carried out of the mine insensible, died. The dead men were not pale or ghastly, but the skin was reddish, and they looked as natural as life.

Cold water absorbs  $CO$  and  $CO_2$ , hence the layer near the ditch may have been purer. Also,  $CO_2$  may have been at the bottom, and  $CO$  at the top, leaving the layer of purest air between.  $CO$  is much more poisonous than  $CO_2$ .

The other accident occurred at Nanticoke, about eight miles above Mocanaqua. It was in the Ross mine, which was the vein

nearest the surface, and worked only for the superior quality of coal which was obtained, for it was not a large vein.

There were two surface openings to the mine—a slope where the coal was hoisted to the surface, and an air-shaft, over which is a large fan for ventilating the mine. At a distance of about 3000 feet from the air-shaft was a large culm bank, where the dirt from this and other mines had been accumulating for years; it is about 200 feet high, and covers about 5 acres of ground. The ground under this had been a swamp, and it contained a large quantity of water. Between the vein of coal (300 feet below the surface) and the surface there was a layer of quicksand; the top rock directly underneath this was weak, and rather of a shelly nature, probably partly caused by the action of the water upon it.

On account of the great weight under the culm bank, the top rock gave way on the 18th of December, 1885, and an immense quantity of quicksand, mixed with culm, run down and filled up the mine. The greater number of men in the mine at the time of the accident escaped through the air-shaft, but there were twenty-three men on the opposite side of the break-in from the air-shaft, and these were cut off from all escape.

Work was at once commenced at two points to extricate these unfortunate men; a tunnel was started from the air-shaft round to the other end of the mine where the men were, and work was started in the slope to take out the mass of sand and culm which was packed in there.

This work was very dangerous, for in the tunnel there was a fall of waste material, followed by a rush of black damp, which is a very poisonous gas, and this led to the conclusion that the imprisoned men had been smothered by this gas. As the debris was cleared away in the slope, the mass of sand and culm would again rush in, filling up the gangway, and endangering the lives of the workmen. These means had to be given up, and it was the general conclusion that the men were dead, for over a month had elapsed since the occurrence of the accident. However, the Company, willing to do all that they could, started to drill a hole from the surface to the mine, at a point near where they thought the miners were. These were not successful in the first attempt, but on trying again, a hole was put through the quicksand into the mine, but nothing was discovered that would indicate that the men were alive, so that all attempts to rescue them were abandoned by the Company.



It is highly probable that the men were smothered soon after the accident by the black damp which filled the mine. E. S. S.

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### RAINFALL AT BETHLEHEM, PA.

The town of Bethlehem is in Lat.  $40^{\circ} 37'$  N. and  $75^{\circ} 23'$  W., and is located on the north bank of the Lehigh River, ten miles from its junction with the Delaware. On the south bank the Lehigh, or South Mountain, rises gradually to an elevation of 900 feet above tide; the summit being a mile and a-half from Bethlehem. To the north lies an undulating country—the valley between the Blue Mountain and the South Mountain. The former is 18 miles distant, and has a uniform elevation of 1,500 feet. The direction of the valley is S. W. by W. The town is situated on a hill, sloping to the S. and W., and is bounded on the west by the Manocacy creek, flowing from the north. The Lehigh canal follows the course of the river on its north bank. The river has an elevation of 220 feet, while the highest elevation of the town is 350 feet at a point on E. Broad street.

The observations which form the basis of this article were carefully recorded and very kindly furnished by Mr. J. E. Luckenbach, who began his observations in July, 1877. His rain-gauge consists of a cylindrical, galvanized iron vessel, 10 inches in diameter and 12 inches deep, in which the rain is caught. It is placed at the surface of the ground, twenty feet west of his house, which is on the west side of Main street, just north of Broad. The elevation here is about 270 feet above tide, or 40 feet above the Manocacy creek, which is 200 ft. distant. The rainfall is measured in a cylindrical glass vessel, on which is a decimal scale, each main division corresponding to one-tenth of an inch, these being subdivided into tenths give the rainfall to hundredths of an inch.

For the last six months of the year 1877, the monthly rainfall was as follows: July, 6.50 inches; August, 6.64; September, 3.23; October, 6.31; November, 5.40; and for December, 1.60 inches; making a total of 29.68 inches. The following table gives the monthly and yearly rainfall at Bethlehem from Jan. 1, 1878 to Jan. 1, 1886.\*

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\* The rainfall for 1886 is as follows: January, 3.63 inches; February, 4.69; March, 4.08; April, 2.98, and for May, 5.59 inches.

	1878	1879	1880	1881	1882	1883	1884	1885	M'thly M'n.
Jan.	4.52	none	2.95	4.06	3.32	4.32	2.38	4.43	3.242
Feb.	3.25	1.23	2.86	2.43	3.90	4.04	4.85	3.65	3.276
Mar.	2.75	3.41	4.13	5.48	4.91	2.71	5.04	1.04	3.684
Apr.	2.92	3.98	3.50	1.00	2.19	2.79	2.41	2.36	2.644
May.	4.65	2.17	1.26	2.87	6.58	2.88	2.86	2.29	3.195
June.	3.50	8.38	3.88	6.08	3.28	8.62	4.76	1.06	4.945
July.	5.28	4.04	4.17	1.36	2.77	4.52	8.13	2.76	4.129
Aug.	2.03	6.03	2.50	0.59	3.54	1.55	2.49	9.17	3.487
Sept.	2.49	1.90	2.47	0.90	5.25	4.20	1.03	0.55	2.348
Oct.	3.40	0.81	1.85	2.90	2.70	5.16	3.64	4.92	3.172
Nov.	3.44	1.84	2.73	2.72	1.32	1.54	2.71	4.28	2.572
Dec.	5.60	5.54	1.71	4.61	1.62	2.59	6.05	1.60	3.665
Ann'al Rain-fall.	43.83	39.33	34.01	35.00	41.38	44.92	46.35	38.11	40.36

From this table it is seen that the mean annual rainfall is 40.36 inches. One cannot fail to note the secular variation in the annual rainfall; for the first three years it shows a gradual decrease, then a corresponding rise for four years, which is quite remarkable in its regularity. In 1880 the annual rainfall was a minimum, 34.01 inches, and reached a maximum of 46.35 inches in 1884. Although the seasons here are not so marked by an abundance or a want of rain as in the tropics, still there is some difference in rainfall. For the Spring months, the mean is 9.52 inches; for Summer, 12.76 inches; for Fall, 8.09 inches, and for Winter, 10.18 inches. The Fall months might be considered the dry season, the remainder of the year constituting the wet season.

From the record of the number of days given in the following table, in which rain fell, it is found that rains occur with about the same frequency in Winter as in Summer, and in Spring as in Fall, which shows that the showers are heaviest in Spring and Summer.

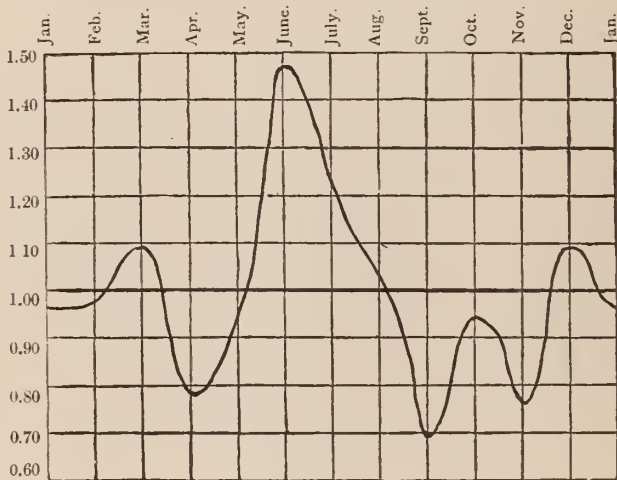
	1881	1882	1883	1884	1885	Mean.
Jan.	4	4	8	9	5	6.0
Feb.	3	6	9	8	6	6.4
Mar.	5	6	4	6	5	5.2
Apr.	2	4	6	4	8	4.8
May.	7	11	9	8	8	8.6
June.	11	7	7	6	6	7.4
July.	5	4	9	8	10	7.2
Aug.	3	6	3	7	9	5.6
Sept.	3	6	6	3	5	4.6
Oct.	8	5	8	10	7	7.6
Nov.	7	5	5	5	10	6.4
Dec.	6	5	8	7	8	6.8
Total	64	69	82	81	87	76.6

From this table it is seen that the average number of days in the year in which rain falls is 76.6, which give an average of 0.53 inches for each day of rain. In 1882, this averaged 0.60 inches, a maximum; and in 1885, it was a minimum, 0.44 inches.

The following is a table of the means with their ratio's to the mean monthly precipitation, which is 3.363 inches.

Month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
M'n Rainfall	3.24	3.28	3.68	2.64	3.19	4.94	4.13	3.48	2.35	3.17	2.57	3.66
Ratio.	0.964	0.974	1.095	0.786	0.950	1.470	1.228	1.037	0.698	0.943	0.765	1.090

With these ratios as ordinates and the months as abscissas, the following curve is drawn, which is a good graphical representation of the relative monthly rainfall :



From this it is readily seen that June is the wettest month, and September the driest. The maximum monthly fall recorded is 9.17 inches for August, 1885; and the minimum is 0.0 inches for January, 1879.

Since 1880 the following rainstorms having a fall of one inch or more have occurred:

Date.	Amt.	Date.	Amt.	Date.	Amt.
1881	Inch's	1883	Inch's	1885	Inch's
Jan. 10	2.45	Feb. 14	1.07	Jan. 6	1.38
Jan. 21	1.06	April 23	1.08	Jan. 11	1.27
Feb. 11	1.13	June 18	1.00	Feb. 9	1.52
Mar. 9	1.36	June 26 & 27	6.46	Feb. 16	1.26
Mar. 19	1.33	July 15	1.92	April 4	1.08
Mar. 31	1.39	Sept. 17	1.37	Aug. 1	1.18
May 6	1.07	Oct. 20 & 23	2.34	Aug. 3	4.45
June 27	1.54	Oct. 29	1.20	Aug. 7	1.10
Dec. 1	1.13	1884		Oct. 21	1.65
Dec. 22	1.05	Feb. 28	1.08	Nov. 2	1.08
1882		Mar. 9	1.77	Nov. 9	1.01
Jan. 21	1.05	Mar. 19	1.26	1886	
Feb. 21	1.34	April 9	1.19	Jan. 4	1.75
Mar. 1	2.16	June 25 & 26	4.22	Feb. 12	1.81
Mar. 27	1.00	July 4	1.50	Feb. 25	1.29
June 26	1.02	July 5	1.07	Mar. 21	1.03
Sept. 11	1.04	July 11	2.71	April 6	1.12
Sept. 22	1.37	July 27	1.00	April 7	1.10
Sept. 26	1.30	Oct. 29	1.20	May 7 & 8	2.83
1883		Dec. 6	2.10	May 13	1.58
Jan. 13	1.00	Dec. 14	1.05		
Jan. 20	1.00				

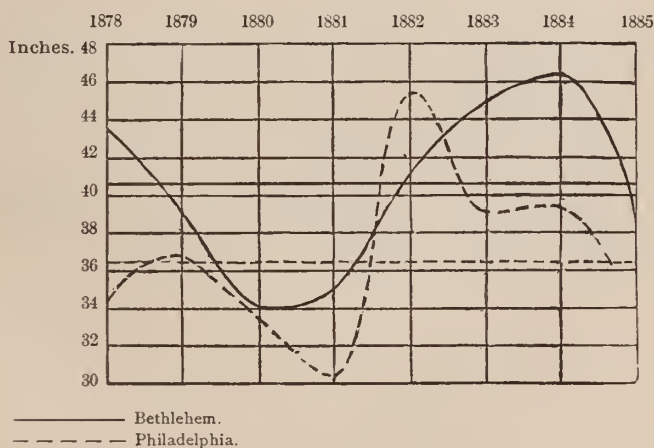


Several noticeable coincidences occur in these rainstorms; the most remarkable being the heavy rainfalls that came on the 26th and 27th of June, for four consecutive years. The June rainfall of last year was exceptionally light, the heaviest shower being only 0.64 inches, and, it might be remarked, that a quarter of an inch of rain fell on the 27th.

On the occasion of the two heavy storms last year, one on July 29th, when 0.94 inches fell in 30 minutes, and the other on August 3d, when 3.00 inches fell in four hours, the culverts were entirely inadequate, several being washed away, and much of the lower part of town was flooded. The storm on July 29 was a mixture of hail and rain, and caused a rise in the Monocacy of five feet in 35 minutes, and in two hours it had risen seven feet, which was unprecedented.

The following is a comparison of the yearly rainfall of Bethlehem with that of Philadelphia.

	1878	1879	1880	1881	1882	1883	1884	1885	Mean.
Bethlehem	43.83	39.33	34.01	35.00	41.38	44.92	46.35	38.11	40.36
Philadelphia	34.53	36.75	33.58	30.20	45.58	39.17	39.34	33.35	36.56



M. D. PRATT.

The American Institute of Mining Engineers held their Forty-fifth meeting at Bethlehem, May 18 to 22, 1886. The attendance was fair, and the meeting was quite a success. Professor A. H.

Richards of Boston Institute of Technology, president of the Institute, delivered his inaugural address on "American Mining Schools." Some of the other papers read at the meeting were: The Geology of the Wyoming Valley in connection with the Nanticoke disaster, by C. H. Ashburner, Engineer in charge of Anthracite Department of Pennsylvania State Geological Survey; Notes on the Attainment of Uniformity in Bessemer Process, Henry M. Howe, of Boston, Mass.; Notes on Some Chinese Coals, J. C. F. Randolph, New York; Lecture on Geology of This (Bethlehem) Region, C. H. Ashburner; a number of papers were read by titles only. The members of the Institute visited various places and works of interest during their stay at Bethlehem, among which were the Bethlehem Iron Company's Works, Lehigh Zinc Works, Lehigh University, Iron Works at Glendon, Phillipsburg and Durham, Works of The Thomas Iron Company at Hokendauqua, The Iron Mines at Rittenhouse Gap, and the Slate Quarries at Chapman and Bangor. A reception to the members of the Institute was given by the citizens of the Bethlehems in the Lehigh University Gymnasium.

The following Alumni of Lehigh were elected as members: Wm. B. Foote, E.M., '84, Superintendent of Mines of Horse Shoe Silver Mining Company, Georgetown, Col.; Francis H. Purnell, C.E., E.M., '83, Berlin, Md.; Geo. H. Jenkins, A.C., Superintendent of Steel Works of Bethlehem Iron Company; David G. Kerr, B.M., '84, Chemist, Wilkinsbury, Pa.; D. K. Nicholson, M.E., '85, with Pennsylvania Steel Company, Steelton, Pa.; H. L. Bowman, B.M., '85, with Bethlehem Iron Co. Rollin H. Wilbur, '85, Assistant to General Superintendent of L. V. R. R., and Chas. A. Luckenbach, '86, were elected associate members.

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#### ALUMNI NOTES.

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1871.

—F. L. Clerc is again at Joplin, Mo., as the superintendent of a new zinc company.

1873.

—W. M. Scudder is the only candidate for president of the Alumni Association.

1875.

—Prof. E. H. Williams' history of the first twenty years of Lehigh University is now in press and will appear in a few days.

1878.

—Charles Bull's address for the Summer is Milford, Conn.

—F. P. Howe is President of the Co-operative Steel Co., Danville, Pa. He had a strike in his mill at Phillipsburg, Pa.

1881.

—T. M. Eynon's address is, care L. Schutte & Co., 12th and Thompson Streets, Philadelphia.

1882.

—E. Ricksecker, topographer on the U. S. Geological Survey, took the field about May 15, in northern California.

1883.

—N. O. Goldsmith has been elected a Junior Member of the American Society of Civil Engineers.

—W. F. More has recently graduated at the Theological Seminary connected with Franklin and Marshall College. He is the first of Lehigh's sons to enter the ministry.

1884.

—Wm. Langston is with Dean & Westbrook, bridge engineers and contractors, 32 Liberty Street, New York.

—A. P. Smith is night editor of the New York *Morning Star*, having severed his connection with the *Tribune*.

—E. F. Hofford is now engaged in an engineering enterprise in Virginia, but we are unable to give his exact address.

1885.

—H. L. Auchmuty is transitman on the Lehigh Valley Railroad corps at Hazleton, Pa.

—J. R. Englebert has been engaged on the water supply of Lykens, Pa.

—H. W. Rowley is with the Dickson Manufacturing Co., at Scranton, Pa.

1886.

—J. S. Seibert is assistant topographer and chief photographer of the party of E. Ricksecker, on the U. S. Geological Survey in northern California.

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*Nature* of May 6 contains a review of the contents of the last number of this Journal.

A Key to Merriman's Mechanics of Materials has recently been published by Wiley & Son, of New York.

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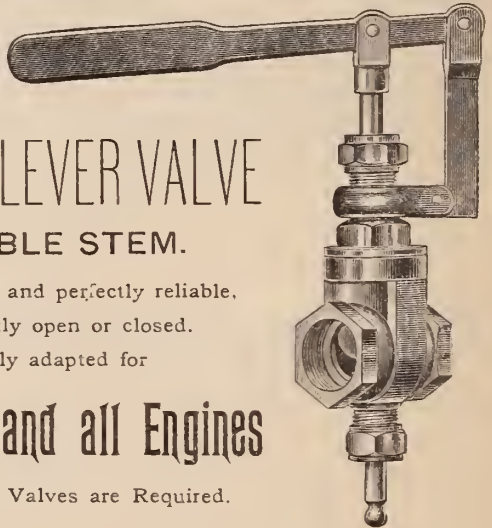
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